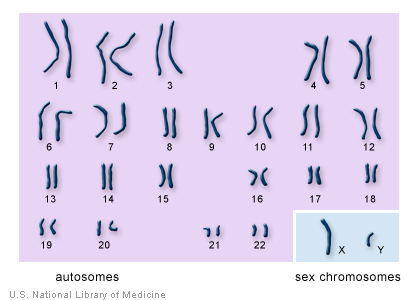
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**Unit 7, Part 3 Notes: Sex-Linked Traits and Dihybrid Crosses**

Pre-AP Biology, Mrs. Krouse

**What types of chromosomes are found in a human cell (review from Unit 5 – Cell Division)?**

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1. The image to the right is called a karyotype. In the space below, describe what is shown in a karyotype.
2. How many chromosomes are found in a human cell? How many pairs of chromosomes?
3. According to the image, there are two types of chromosomes—autosomes and sex chromosomes. Which pairs of chromosomes are autosomes, and which pair is the sex chromosomes?
4. What are the two types of sex chromosomes?
5. Which sex chromosomes are found in females, and which sex chromosomes are found in males?
6. How are the traits controlled by genes on autosomes different from the traits controlled by genes on sex chromosomes?

**How can we track the inheritance of traits controlled by genes found on sex chromosomes?**

1. All the traits we have investigated so far through Punnett squares are controlled by genes found on ***autosomes***.

1. We can also track the inheritance of traits controlled by genes found on the ***sex chromosomes***. These traits are called ***sex-linked traits***.
2. The term “sex-linked traits” is a good example of a biology term that makes sense when you break it down into its parts. What does “linked” mean?
3. Though we can study traits controlled by genes found on the Y chromosome, we will focus on traits found on the X chromosome. These traits are called ***X-linked traits.***
4. Remember, genes found on autosomes have different alleles. How did we define alleles in our Part 1 Notes?
5. Just like genes found on autosomes, genes found on the X chromosome have different alleles as well. For example, there is a disease called hemophilia that is caused by a recessive allele on the X chromosome. Hemophilia causes difficulty with blood clotting, which could result in major bleeding from a minor cut. Nowadays we have medicines for hemophilia patients that assist with blood clotting, but it used to be very difficult to treat.
6. We will assign the hemophilia allele the abbreviation Xh. We include the “X” because the gene is found on the X chromosome. We include the “h” because the hemophilia allele is recessive to the normal allele. For these same reasons, we will assign the normal allele the abbreviation XH.
7. The chart below shows the possible genotypes for males and females. Let’s identify the sex (male or female) associated with each genotype. We will also identify the phenotype (i.e., normal blood clotting or hemophilia) associated with each allele.

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| **Genotype** | **Sex** | **Phenotype** |
| XH XH |  |  |
| XH Xh |  |  |
| Xh Xh |  |  |
| XHY |  |  |
| XhY |  |  |

1. Traits like hemophilia that are controlled by a recessive allele on the X chromosome are more common in one sex than the other. Based on the chart above, which sex (male or female) would be more likely to display an X-linked recessive trait? Explain your answer.

1. Women with the genotype XHXh are called carriers. This means they do not have hemophilia but can pass the recessive hemophilia allele down to their children.
2. Suppose a man who does not have hemophilia marries a woman who is a carrier of the hemophilia allele. Let’s do a Punnett square analysis of this scenario.

Why do we use a Punnett square?

In a Punnett square, the letters on the top and left side of the square are supposed to represent single alleles found in gametes from each parent. What are gametes?

What are the genotypes of the two parents from the scenario described on the previous page?

Set up your Punnett square in the space below. Put the alleles found in the mother’s gametes on the top of the square and the alleles found in the father’s gametes on the left side of the square. Then fill in the genotypes of their potential children in the four boxes inside the Punnett square.

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Describe the sex and phenotype frequencies seen in the offspring. Express your frequencies as percentages.

**How can we track the inheritance of two traits at once?**

1. Up until this point, we have been setting up and analyzing Punnett squares that show ***monohybrid crosses***, which track the inheritance of one trait at a time. These Punnett squares have four boxes to represent the four possible offspring genotypes.
2. Now, we will set up and analyze Punnett squares that show ***dihybrid crosses***, which track the inheritance of two traits at a time. These Punnett squares have 16 boxes to represent the 16 possible offspring genotypes.
3. Usually, when we are analyzing dihybrid Punnett squares, we focus on the offspring phenotype frequencies. We can determine offspring genotype frequencies, but there are often so many possible genotypes that it becomes very complicated.
4. Let’s say we are tracking the inheritance of flower and leaf color in plants. Purple flowers (P) are dominant over white flowers (p), and green leaves (G) are dominant over yellow leaves (g). Suppose we want to determine the offspring phenotype frequencies for a cross between parents with the following genotypes:

Parent 1: GgPp

Parent 2: GgPp

Notice that with a genotype for two traits, we typically put the alleles in alphabetical order. G comes before P in the alphabet!

We would say these parent plants are both heterozygous for both the traits (i.e., flower and leaf color),

1. Remember that the top and left side of a Punnett square represent alleles carried by gametes (sex cells) that combine during fertilization to create offspring. These offspring are represented by the genotypes that are actually inside the Punnett square.
2. If the offspring need to have two alleles for each trait (ex: two P’s and two G’s), each gamete will need to have one allele for each trait (ex: one P and one G).
3. To determine the alleles that go into each gamete on the top and left side of your dihybrid Punnett square, use the FOIL method on each of the parent genotypes. We will do this for each of the parent genotypes given in #21 in the space below.
4. Now, let’s put these “gamete alleles” on the top and left side of our Punnett square. Then, we will fill in the offspring genotypes inside the boxes of the Punnett square. We will always put G’s before P’s because G comes before P in the alphabet. We will also write capital letters before lowercase letters (ex: Gg and Pp).

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1. Now we will count our offspring phenotype frequencies. (The genotype frequencies are too tedious to count. It would take forever!) What methods does Mrs. Krouse recommend for counting offspring phenotype frequencies? Use one of these methods on your Punnett square above.
2. What are the offspring phenotype frequencies? Let’s write these frequencies in the space below as fractions and as a ratio.
3. It’s important to remember that these same offspring phenotype frequencies ALWAYS show up when we do a dihybrid cross with two parents that are both heterozygous for both traits. Written in more general terms (i.e., dominant and recessive phenotypes), these frequencies are…
4. Let’s do another example problem. In mice, the ability to run normally is a dominant trait. Mice with this trait are called running mice (R). The recessive trait causes mice to run in circles only. Mice with this trait are called waltzing mice (r). Hair color is also inherited in mice. Black hair (B) is dominant over brown hair (b).

Let’s cross a homozygous running, heterozygous black mouse with a waltzing brown mouse.

1. What are the genotypes of the two parent mice?
2. What are the “gamete alleles” that will go on the top and left sides of the Punnett square? (Remember to use the FOIL method!)
3. Now let’s fill in our Punnett square.

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1. What are the offspring phenotype frequencies? Write these frequencies as fractions and as a ratio.